VIIRS-NPP Surface Reflectance User's Guide

Collection 1

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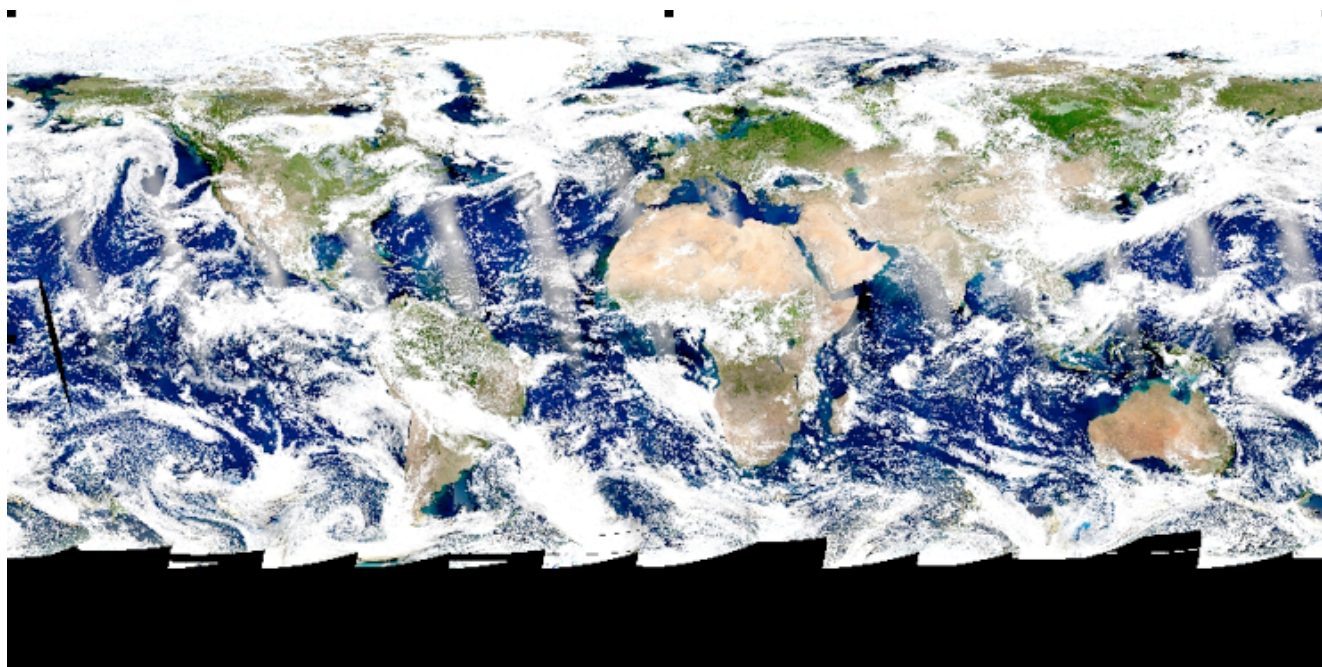
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1. Product description

Most satellite data processing systems recognize five distinct levels of processing. Level 0 data is raw satellite feeds: level 1 data has been radiometrically calibrated, but not otherwise altered. Level 2 data is level 1 data that has been atmospherically corrected to yield a surface reflectance product. Level 3 data is level 2 data that has been gridded into a map projection, and usually has also been temporally composited or averaged. Level 4 data are products that have been put through additional processing. All data up to and including level 2 are in an ungridded orbital swath format, with each swath typically cut into small segments, or ***granules***, to facilitate processing. Data at level 3 and up are geolocated into a specific map projection, with the geolocated products typically in a set of non-overlapping ***tiles***.

The advantage of level 3 data over less processed forms of data is that each pixel of L3 data is precisely geolocated; a disadvantage is that the process of compositing or averaging that results in L3 data limits the usefulness of the L3 product. The Level 2G format, consisting of gridded Level 2 data, was developed as a means of separating geolocating from compositing and averaging. The L2G format preserves all the data that maps to a given pixel as observations at that pixel. Programs which produce level 3 data can then have all available data at each pixel to choose from, without having to geolocate everything themselves. An additional step of processing, level 2G-lite, provides a minimal level of compositing of daily level 2G data.

Surface reflectance for each pixel and for 12 bands (see Table 1) is obtained by adjusting top-of-atmosphere reflectance to compensate for atmospheric effects. Corrections are made for the effects of molecular gases, including ozone and water vapor, and for the effects of atmospheric aerosols. The inputs to the surface reflectance algorithm are top- of- atmosphere reflectances for the VIIRS visible bands (NPP_VMAE_L1, NPP_VIAE_L1), VIIRS cloud mask (NPP-CMIP_L2), aerosol optical thickness and aerosol models (NPP_VAOTIP_L2, NPP_VAMIP_L2), and atmospheric data obtained from NCEP reanalysis (surface pressure, atmospheric precipitable water and ozone concentration).

Table 1. VIIRS bands included in Surface Reflectance products and nearest equivalent MODIS bands (not exact matches).

Band Name[a]	Band center (µm)	Bandwidth[b] (µm)	Nearest equivalent MODIS band
M1	.415	.020	8
M2	.445	.018	9
M3	.490	.020	3
M4	.555	.020	4
I1	.640	.080	1
M5	.673	.020	1
I2	.865	.039	2
M7	.865	.039	2
M8	1.24	.020	5
I3	1.61	.060	6
M10	1.61	.060	6
M11	2.25	.050	7

[a] M indicates band with a nadir resolution of 750 m, I indicates band with a nadir resolution of 375 m.
[b] full width half maximum (FWHM)

2. Overview of VIIRS/NPP processing

Surface reflectance is the fraction of incoming radiation at a particular wavelength or bandpass that is reflected from the land surface. The NPP/ VIIRS surface reflectance products are estimates of surface reflectance in each of the VIIRS reflective bands I1- I3, M1- M5, M7, M8, M10, and M11. Level 2 surface reflectance products are produced for the same swath data sets as the Land PEATE Level 1B swaths, each of which contains approximately five minutes' worth of data. Surface reflectance for each moderate-resolution (750m) or imagery-resolution (375m) pixel is retrieved separately in for the Level 2 products. Level 2G and Level 3 products are generated by performing spatial and temporal aggregation to 500m, or 1km grids, over daily, or 8-day, time periods.
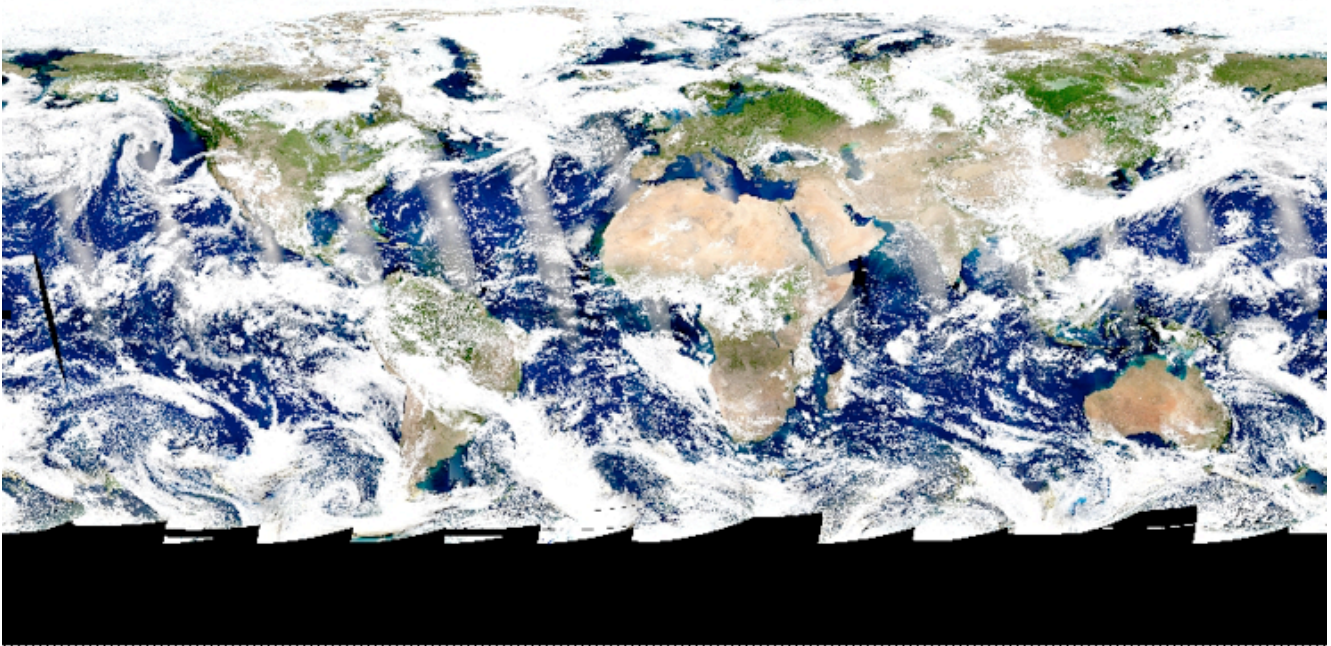

Figure 1. An RGB-image derived from NPP_SRFLIP_CMG.A2015185.C1_03110.2015250181505.hdf

2.1. VIIRS surface reflectance data products

The following surface reflectance products are generated at Land PEATE and are distributed from the LAADS: Two Level 2 VIIRS surface reflectance products (imagery-resolution NPP_SRFLIIP_L2 and moderate-resolution NPP_SRFLMIP_L2), three Level 2G surface reflectance products (NPP_DSRFLD_L2GD, NPP_DSRF1KD_L2GD, and NPP_DSRFHKD_L2GD), a global CMG- grid daily L3 surface reflectance (NPP_SRFLIP_CMG), and two multi- day surface reflectance products (NPP_D8SRF1KM_L3D and NPP_D8SRFHKM_L3D). See Table 2.

Please note that not all Land PEATE Surface Reflectance products are publically available. This User's Guide is meant to be a guide for the use of publically available VIIRS/NPP products, so it is the publically available products that are described here in detail.

Table 2: Summary of land surface reflectance products produced at the Land PEATE

Products	ESDT	Description
Surface Reflectance (L2 Daily Swath product)	NPP_SRFLMIP_L2	VIIRS/NPP Surface Reflectance 5-Min Swath IP 750m Bands M1- M5, M7-M8, M10-M11.
	NPP_SRFLIIP_L2	VIIRS/NPP Surface Reflectance 5-Min Swath IP 375m Bands I1- I3
Surface Reflectance (L2G Daily Tiled products)	NPP_DSRF1KD_L2GD	VIIRS/NPP Surface Reflectance Daily L2G Global DDR 1km SIN Grid Day. Bands M1- M5, M7-M8, M10-M11. Input is NPP_SRFLMIP_L2.
	NPP_DSRFHKD_L2GD	VIIRS/NPP Surface Reflectance Daily L2G Global DDR 500m SIN Grid Day. Bands I1- I3 Input is NPP_SRFLIIP_L2.
	NPP_DSRFLD_L2GD	VIIRS/NPP Surface Reflectance Daily 1km and 500m L2G lite Bands I1- I3 (500m), Bands M1- M5, M7-M8, M10-M11 (1 Km) Inputs are NPP_SRFLMIP_L2 and NPP_SRFLIIP_L2
Surface Reflectance (L3 8-day Composite Products)	NPP_D8SRF1KM_L3D	VIIRS/NPP 8-Day Surface Reflectance L3 1km SIN Grid. Bands M1- M5, M7-M8, M10-M11. Input is NPP_DSRF1KD_L2GD.
	NPP_D8SRFHKM_L3D	VIIRS/NPP 8-Day Surface Reflectance L3 500m SIN Grid. Bands I1- I3 Input is NPP_DSRFHKD_L2GD
Surface Reflectance (L3 Daily CMG Products)	NPP_SRFLIP_CMG	VIIRS/NPP Daily Surface Reflectance L3 Global DDR 0.05°x0.05° grid CMG. Bands I1- I3, M1- M5, M7-M8, M10-M11 (M12-16 also added) Inputs are NPP_SRFLMIP_L2 and NPP_SRFLIIP_L2

2.2. NPP/ VIIRS Level 2 Surface Reflectance Product Description

All surface reflectance products are produced under daytime conditions only. In the LPEATE/IDPS (AS3001) versions of the surface reflectance products, water pixels and pixels that are low quality due to conditions such as the presence of aerosols, are excluded from processing prior to operational build versions prior to Mx83. The product is produced under all atmospheric conditions except for night and seawater when using algorithm build version Mx83 and beyond. Pixels, when not produced, are replaced by fill values in the Level 2 products, and are not included in the Level 3 products.

2.3. NPP/ VIIRS Level 2G Surface Reflectance Product Description

The NPP/ VIIRS Level 2G surface reflectance products are composed of all available surface reflectance observations for a given day over a set of tiles with global coverage. The tile numbering scheme and boundaries are the same as they are for MODIS. The first set of observations for each data set and grid

cell are stored as a two- dimensional data set. Additional data layers are stored in a compacted format. Pixels, when not produced, are replaced by fill values in the Level 2G products, and are not included in the Level 3 products.

The Land PEATE produces three Level 2G surface reflectance products, one containing data from the moderate resolution bands projected to a 1km grid (NPP_DSRF1KD_L2GD), one containing data from the imagery- resolution bands projected to a 500m grid (NPP_DSRFHKD_L2GD), and one containing both the moderate- resolution and imagery- resolution bands along with sun/ sensor geometry fields (NPP_DSRFLD_L2GD). The NPP_DSR1KDI_L2GD 1km Level 2G product is generated using image-ry- resolution pointer data, while the NPP_DSRF1KD_L2GD 1km Level 2G product is generated using moderate- resolution pointer data, but they both contain moderate- resolution band (M-band) surface reflectances. The NPP_DSRFLD_L2GD

The algorithm runs for each tile in the sinusoidal grid (Figure 1) for each day, and is run on all NPP/VIIRS level 2 granules that map to the tile for that day. The number of observations at each pixel is determined not only by the number of orbits at that location (one at the equator and up to 15 at the poles), but also by the spread of observational coverage of off-nadir pixels.
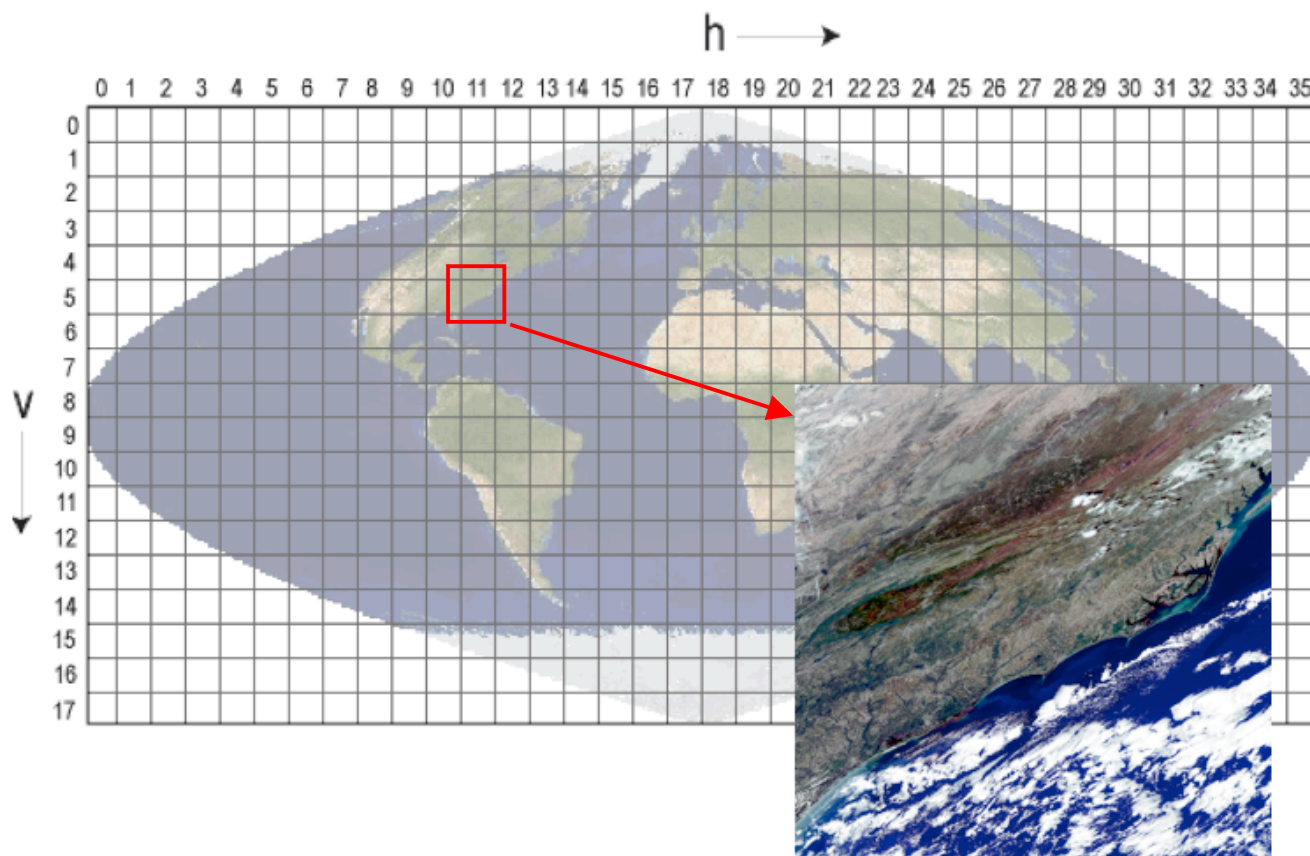

Figure 2. The NPP/VIIRS sinusoidal grid consists of 460 nonoverlapping tiles which measure approximately 10° x 10°. Data from an example tile (tile h11v05, derived from NPP_DSRF1KD_L2GD.A2015293.h11v05.C1_03002.2015295110654.hdf) is shown as a RGB-image.

2.4. NPP/ VIIRS Level 3 Surface Reflectance Product Description

There are four Level 3 surface reflectance products produced at LPEATE, one tiled daily, one global CMG- grid daily, and two 8- day composite products. The Level 3 daily tiled surface reflectance product, NPP_DSRFIP_L3, is produced at (resolution), on the standard MODIS tile grid. The Level 3 daily CMG product, NPP_SRFLIP_CMG, is produced at 0.05 degree resolution on a global grid. One of the 8- day products, NPP_D8SRF1KM_L3D, is produced at 1km resolution, and the other, NPP_D8SRFHKM_L3D, is produced at 500m resolution.

Each of the products are produced for a subset of the VIIRS reflective bands. NPP_DSRFIP_L3 is produced for M1- M5, M7, M8, M10, and M11. NPP_D8SRFHKM_L3D is produced for bands I1- I3, and NPP_SRFLIP_CMG is produced for bands I1- I3 and for M1-M5, M7, M8, M10, and M11. NPP_DSRF1KM_L3D is produced for (M1- M9?).

In the LPA (AS3002) and reprocessed (e.g. C11 in AS3110) versions of the surface reflectance products, all daytime pixels are processed, but lower quality data are not used in the Level 3 composites where higher quality data are available.

For each pixel, the compositing steps are

1) Observations from the same orbit are composited by observational coverage. Observations with the highest coverage are saved, and the rest discarded. This yields a list of one observation from each orbit.
2) Each orbit's observation is then assigned a score, based upon whether it is flagged for cloud, cloud shadow, high aerosol or low aerosol, or contains high view angle or low solar zenith angle. The lowest score, 0, is assigned to observations with fill values for data. The remaining scores are

```
 1 BAD           data derived from a faulty or poorly corrected L1B pixel
    2 HIGHVIEW      data with a high view angle (60 degrees or more)
    3 LOWSUN        data with a high solar zenith angle (85 degrees or more)
    4 CLOUDY        data flagged as cloudy or adjacent to cloud
    5 SHADOW        data flagged as containing cloud shadow
    6 UNCORRECTED   data flagged as uncorrected
    7 CLIMAEROSOL   data flagged as containing the default level of aerosols
    8 HIGHAEROSOL   data flagged as containing the highest level of aerosols
    9 SNOW          data flagged as snow
   10 GOOD          data which meets none of the above criteria
```

The observation with the highest score and the lowest view angle is selected for the MOD09A1 and MOD09Q1 outputs.

3. Detailed product descriptions

3.1. Description and Science Data Sets

3.1.1. NPP_SRFLMIP_L2

VIIRS/NPP Surface Reflectance 5-minute L2 Swath IP 750m

Product description: The Surface Reflectance IP algorithm provides VIIRS surface reflectance for bands M1, M2, M3, M4, M7, M8, M10 and M11 at 750m resolution and data Quality flags.

Figure 3. A NPP_SRFLMIP_L2 RGB-image composed of surface reflectance measured by VIIRS bands M3 (red), M4 (green) and M5 (blue) October 09, 2015 over Spain and Morocco. Product granule ID: NPP_SRFLMIP_L2.A2015282.1315.P1_03002.2015283 034527.hdf
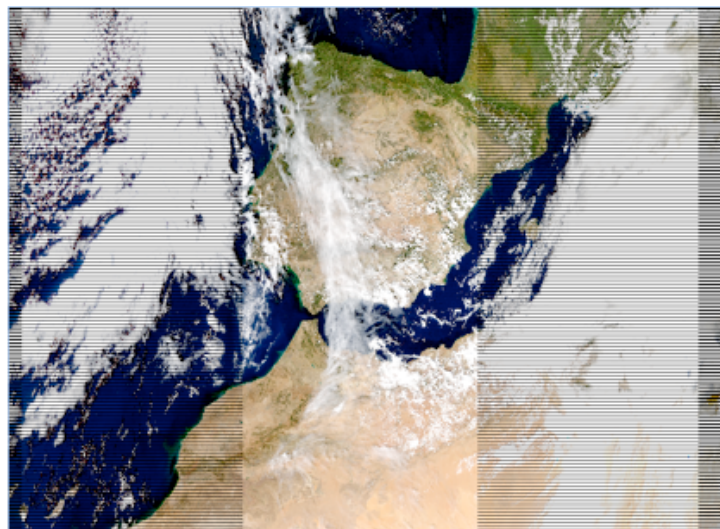
Table 3. Science Data Sets for NPP_SRFLMIP_L2.

Data Group	Science Data Sets (HDF Layers (16))	Units	Data Type	Fill Value	Valid Range	Scale Factor
750 m	750 m Surface Reflectance Band M1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	750 m Surface Reflectance Band M2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	750 m Surface Reflectance Band M3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	750 m Surface Reflectance Band M4	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	750 m Surface Reflectance Band M5	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	750 m Surface Reflectance Band M7	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	750 m Surface Reflectance Band M8	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001

	750 m Surface Reflectance Band M10	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	750 m Surface Reflectance Band M11	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	QUALITY FLAG 1 *(see Table 11)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 2 *(see Table 12)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 3 *(see Table 13)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 4 *(see Table 14)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 5 *(see Table 15)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 6 *(see Table 16)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 7 *(see Table 17)*	Bit field	8-bit unsigned integer	255	0 - 255	NA

3.1.2. NPP_SRFLIIP_L2

VIIRS/NPP Surface Reflectance 5-minute L2 Swath IP 375m

Product description: The Surface Reflectance IP algorithm provides VIIRS surface reflectance for bands I1, I2, I3 at 375m resolution and data Quality flags.

Figure 4. A NPP_SRFLIIP_L2 RGB-image composed of surface reflectance measured by VIIRS bands I1, I2 and I3 on October 09, 2015 over Spain and Morocco. Product granule ID: NPP_SRFLIIP_L2.A2015282.1315.P1_03002.2015283034527.hdf
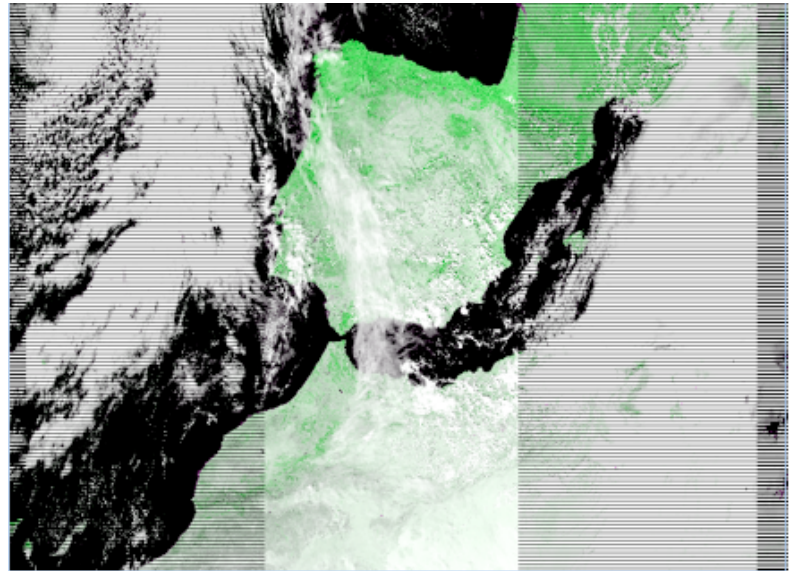

Table 4. Science Data Sets for NPP_SRFLIIP_L2.

Data Group	Science Data Sets (HDF Layers (10))	Units	Data Type	Fill Value	Valid Range	Scale Factor
375 m	375 m Surface Reflectance Band I1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	375 m Surface Reflectance Band I2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	375 m Surface Reflectance Band I3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.001
	QUALITY FLAG 1 *(see Table 11)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 2 *(see Table 12)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 3 *(see Table 13)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 4 *(see Table 14)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 5 *(see Table 15)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 6 *(see Table 16)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 7 *(see Table 17)*	Bit field	8-bit unsigned integer	255	0 - 255	NA

3.1.3. NPP_DSRF1KD_L2GD

VIIRS/NPP Surface Reflectance Daily L2G Global DDR 1 km SIN Grid day

Product description: NPP_DSRF1KD_L2GD provides daily VIIRS/NPP surface reflectance at 1km for bands M1-5, M7-8, M10-11. The best observations during a 24-hour period, as determined by overall pixel quality and observational coverage, are matched geographically according to corresponding 1 km Pointer Files. Quality information for this product is provided at three different levels of detail: for individual pixels, for each band and each resolution, and for the whole file.

Figure 5. RGB (M3, M4 and M5) NPP_DSRF1KD_L2GD product on August 6th 2015. Product granule ID: NPP_DSRF1KD_L2GD.A2015218.h30v10.C1_03002.201521055809.hdf
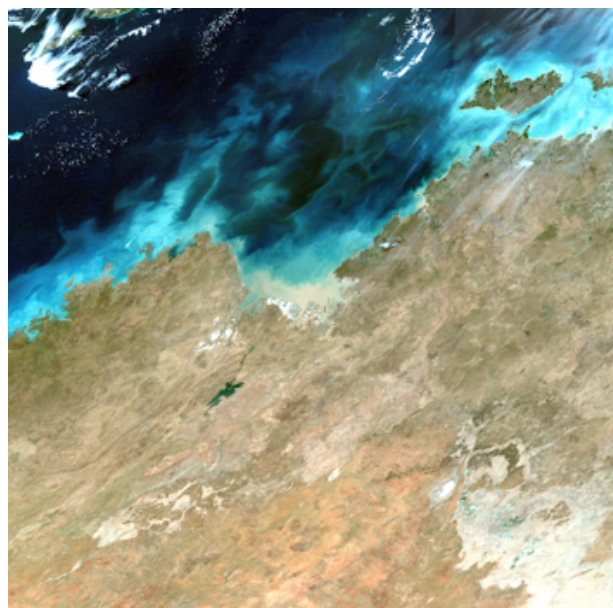
Table 5. Science Data Sets for NPP_DSRF1KD_L2G.

Data Group	Science Data Sets (HDF Layers (18))	Units	Data Type	Fill Value	Valid Range	Scale Factor
1 km	1km Surface Reflectance Band M1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1km Surface Reflectance Band M2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1km Surface Reflectance Band M3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1km Surface Reflectance Band M4	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1km Surface Reflectance Band M5	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1km Surface Reflectance	Reflectance	16-bit signed	-28672	-100 - 16000	0.0001

Band M7		integer			
1km Surface Reflectance Band M8	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1km Surface Reflectance Band M10	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1km Surface Reflectance Band M11	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
QUALITY FLAG 1 (see Table 11)	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 2 (see Table 12)	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 3 (see Table 13)	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 4 (see Table 14)	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 5 (see Table 15)	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 6 (see Table 16)	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 7 (see Table 17)	Bit field	8-bit unsigned integer	255	0 - 255	NA
Orbit and Coverage (see Table 25)	Bit field	8-bit unsigned integer	15	0 - 255	NA
Number of observations	NA	8-bit signed integer	-1	0 - 127	NA

3.1.4. NPP_DSRFHKD_L2GD

VIIRS/NPP Surface Reflectance Daily L2G Global DDR 500 m SIN Grid day

Product description: NPP_DSRFHKD_L2GD provides daily VIIRS/NPP surface reflectance at 500 m for bands I1, I2 and I3. The best observations during a 24-hour period, as determined by overall pixel quality and observational coverage, are matched geographically according to corresponding 500 m Pointer Files. Quality information for this product is provided at three different levels of detail: for individual pixels, for each band and each resolution, and for the whole file

Figure 6. RGB (I1, I2 and I3) product on August 6th 2015. Product granule ID: NPP_DSRFHKD_L2GD.A2015218.h30v10.C1_03002.2015221055809.hdf

Table 6. Science Data Sets for NPP_DSRFHKD_L2G.

Data Group	Science Data Sets (HDF Layers (5))	Units	Data Type	Fill Value	Valid Range	Scale Factor
500 m	500m Surface Reflectance Band I1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	500m Surface Reflectance Band I2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	500m Surface Reflectance Band I3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	Orbit and Coverage *(see Table 25)*	Bit field	8-bit unsigned integer	15	0 - 255	NA
	Number of observations	NA	8-bit signed integer	-1	0 - 127	NA

3.1.5. NPP_DSRFLD_L2GD

VIIRS/NPP Surface Reflectance Daily L2GD 500 m and 1 km

Product description: NPP_DSRFLD_L2GD provides VIIRS/NPP bands M1-5, M7-8 and M10-11 daily surface reflectance at 1 km resolution and band I1, I2 and I3 at 500 m observation and geolocation statistics.

Figures 7. A VIIRS NPP_DSRFLD_L2GD product composed of surface reflectance data measured by bands M3, M4 and M5 (Top) and I1, I2 and I3 (Bottom) on October, 10th 2015 over the West Africa coast. Granule ID: NPP_DSRFLD_L2GD.A2015283.h16v06.C1_03002.2015284152439.hdf
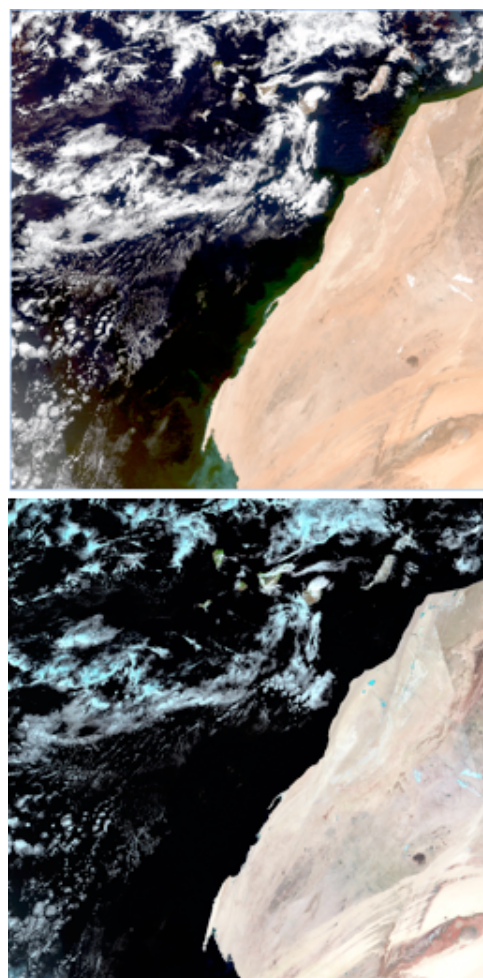
Table 7. Science Data Sets for NPP_DSRFLD_L2GD

Data Group	Science Data Sets (HDF Layers (29))	Units	Data Type	Fill Value	Valid Range	Scale Factor
1 km	Num_observations_1km	None	8-bit signed integer	-1	0 - 127	NA
	Sensor Zenith Angle	Degree	16-bit signed integer	-32767	0 - 18000	0.01
	Sensor Azimuth Angle	Degree	16-bit signed integer	-32767	-18000 - 18000	0.01
	Solar Zenith Angle	Degree	16-bit signed integer	-32767	0 - 18000	0.01
	Solar Azimuth Angle	Degree	16-bit signed integer	-32767	-18000 - 18000	0.01
	Orbit_pnt: Orbit Pointer	None	8-bit signed integer	-1	0 - 15	NA
1 km	Observations coverage 1km	Percent	8-bit signed integer	-1	0 - 100	NA
	1 km Surface Reflectance Band M1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001

	1 km Surface Reflectance Band M2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1 km Surface Reflectance Band M3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1 km Surface Reflectance Band M4	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1 km Surface Reflectance Band M5	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1 km Surface Reflectance Band M7	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1 km Surface Reflectance Band M8	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1 km Surface Reflectance Band M10	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	1 km Surface Reflectance Band M11	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	QUALITY FLAG 1 *(see Table 11)*	Bit Field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 2 *(see Table 12)*	Bit Field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 3 *(see Table 13)*	Bit Field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 4 *(see Table 14)*	Bit Field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 5 *(see Table 15)*	Bit Field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 6 *(see Table 16)*	Bit Field	8-bit unsigned integer	255	0 - 255	NA
	QUALITY FLAG 7 *(see Table 17)*	Bit Field	8-bit unsigned integer	255	0 - 255	NA
500 m	num_observations 500 m	None	8-bit signed integer	-1	0 - 127	NA
	500m Surface Reflectance Band I1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	500m Surface Reflectance Band I2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	500m Surface Reflectance Band I3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	Obs_cov_500m: Observation coverage	Percent	8-bit signed integer	-1	0 - 100	0.01
	iobs_res: Observation number	None	8-bit unsigned integer	255	0 - 254	NA

3.1.6. NPP_D8SRF1KM_L3D

NPP/VIIRS Surface Reflectance Daily L3 1km SIN Grid Deg CMG

Product description: NPP_D8SRF1KM_L3D provides VIIRS/NPP band M1-M5, M7-8, M110-11 surface reflectance at 1km resolution. It is a level-3 composite of 1 km resolution NPP_DSRF1KD_L2GD. Each product pixel contains the best possible L2G observation during an 8-day period as selected on the basis of high observation coverage, low view angle, absence of clouds or cloud shadow, and aerosol loading.

Figure 8. RGB product composed of surface reflectance data measured by bands I1, I2 and I3 on October 8th, 2015 over the Eastern America. Granule ID is NPP_D8SRF1KM_L3D.A2015281.h12v04.C1_03002 .2015290223607.hdf
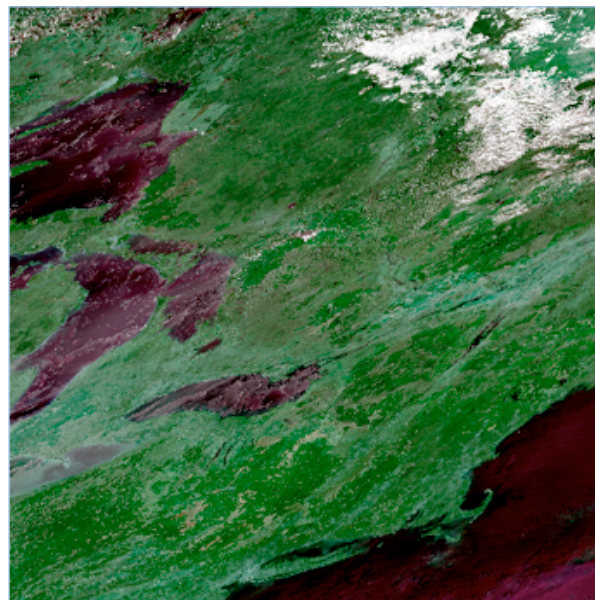
Table 8. Science Data Sets for NPP_D8SRF1KM_L3D.

Science Data Sets (HDF Layers (15))	Units	Data Type	Fill Value	Valid Range	Scale Factor
1 km Surface Reflectance Band M1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M4	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M5	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M7	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M8	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M10	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Surface Reflectance Band M11	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
1 km Reflectance Band Quality (*see Table 19*)	Bit Field	32-bit unsigned integer	1073741824	NA	NA
Solar Zenith Angle	Degree	16-bit signed integer	0	0 - 18000	0.01
View Zenith Angle	Degree	16-bit signed integer	0	0 - 18000	0.01
Relative Azimuth Angle	Degree	16-bit signed integer	0	-18000 - 18000	0.01
1 km State Flags (*see Table 21)*	Bit field	16-bit signed integer	65535	NA	NA
Day of Year	Julian day	16-bit unsigned integer	65535	1 - 366	NA

3.1.7. NPP_D8SRFHKM_L3D

NPP/VIIRS Surface Reflectance 8-Day L3 Global 500 m

Product description: NPP_D8SRFHKM_L3D provides VIIRS band I1-I3 surface reflectance at 500 m resolution. It is a level 3 composite of NPP_DSRFHKD_L2GD. Each pixel contains the best possible L2G observation during an 8-day period as selected on the basis of high observation coverage, low view angle, the absence of clouds or cloud shadow, and aerosol loading.

Figure 9. RGB product composed of surface reflectance data measured by bands I1, I2 and I3 on October 8th, 2015 over the South of France. Part of the Granule ID : NPP_D8SRFHKM_L3D.A2015281.h18v04.C1_03002.2015290103500.hdf
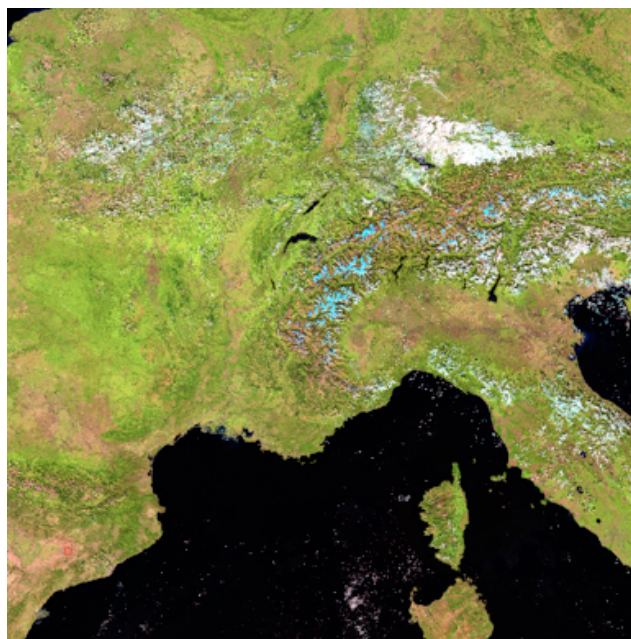
Table 9. Science Data Sets for NPP_D8SRFHKM_L3D

Science Data Sets (HDF Layers (5))	Units	Data Type	Fill Value	Valid Range	Scale Factor
500m Surface Reflectance Band I1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band I2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band I3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Reflectance State QA (*see Table 21*)	Bit Field	16-bit unsigned integer	65535	NA	NA
500m Reflectance Band Quality (*see Table 18*)	Bit Field	16-bit unsigned integer	65535	0 - 32767	NA

3.1.8. NPP_SRFLIP_CMG

NPP/VIIRS Surface Reflectance Daily L3 Global DDR 0.05 Deg CMG

Product description: NPP_SRFLIP_CMG provides VIIRS bands M1-M5, M7-M8, M10-11 and I1-I3 surface reflectance at 0.05-degree resolution. This product is based on a Climate Modeling Grid (CMG) for the purpose of being used in climate simulation models.

Figure 10a. A NPP_SRFLIP_CMG RGB-image composed of surface reflectance measured by NPP/VIIRS bands M3 (Blue), M4 (Green) and M3 (Red) on August 5, 2015.

Product granule ID: NPP_SRFLIP_CMG.A2015217.C1_03002.2015220203835.hdf
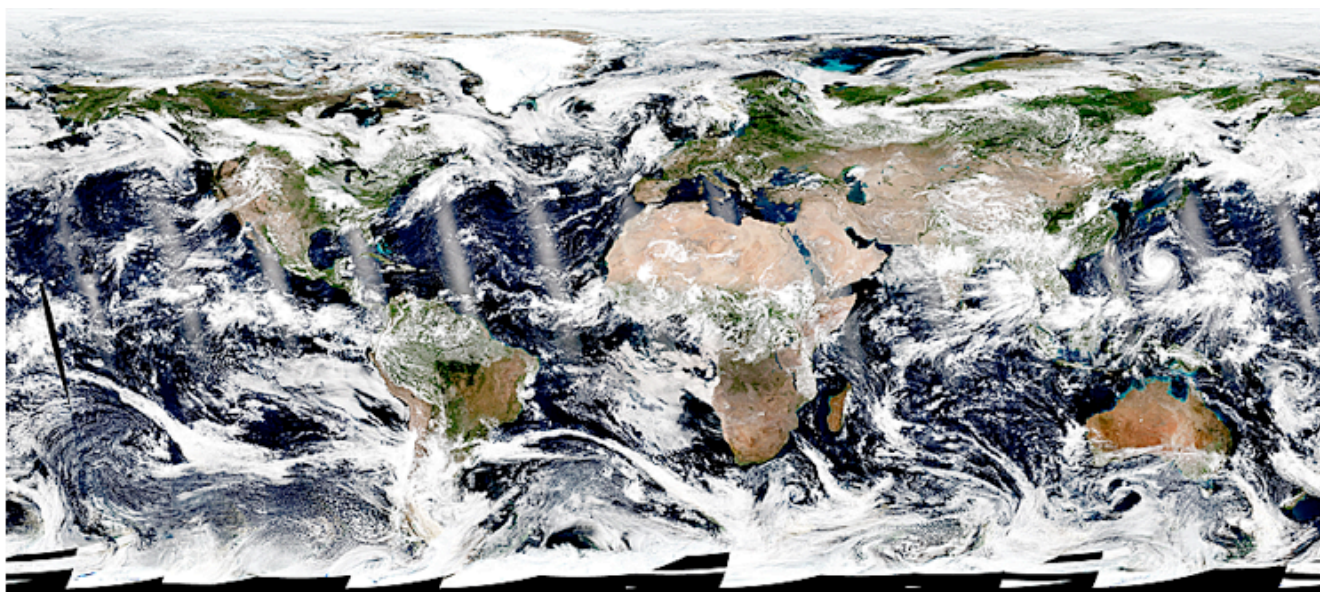

Figure 10b. A NPP_SRFLIP_CMG image composed of surface reflectance measured by NPP/VIIRS bands I1 (Near Infrared) and I2 (Red) on August 5, 2015. Product granule ID: NPP_SRFLIP_CMG.A2015217.C1_03002.2015220203835.hdf
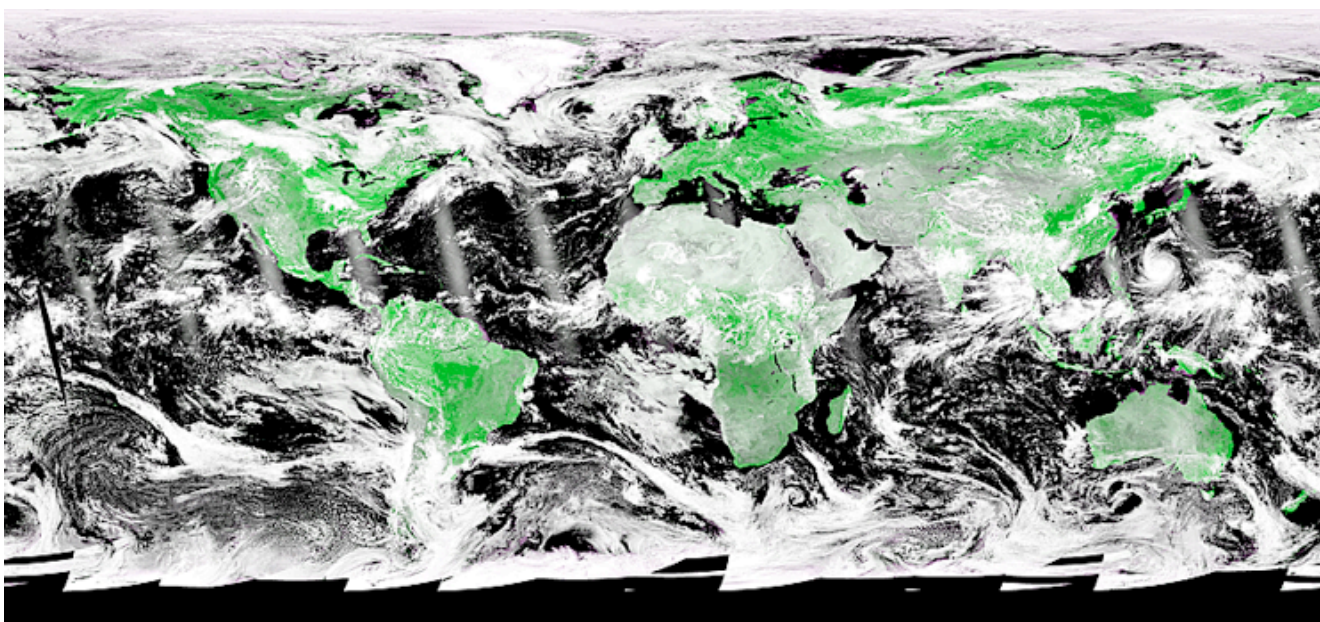
Table 10. Science Data Sets for NPP_SRFLIP_CMG.

Science Data Sets (HDF Layers (25))	Units	Data Type	Fill Value	Valid Range	Scale Factor
Surface Reflectance CMG Band I1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band I2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band I3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
QUALITY FLAG 1 *(see Table 11)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 2 *(see Table 12)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 3 *(see Table 13)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 4 *(see Table 14)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
QUALITY FLAG 5 *(see Table 15)*	Bit field	8-bit unsigned integer	255	0 - 255	NA
Surface Reflectance CMG Band M1	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M2	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M3	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M4	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M5	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M7	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M8	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M10	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance CMG Band M11	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Aerosol Model CMG *(see Table 20)*	None	8-bit unsigned integer	0	0 - 5	1
Aerosol Opt. Thick. at 550 nm CMG	None	16-bit signed integer	60	0 - 3000	0.001
Brightness Temperature CMG Band M12	Degrees K	16-bit unsigned integer	0	0 - 40000	0.01
Brightness Temperature CMG Band M13	Degrees K	16-bit unsigned integer	0	0 - 40000	0.01
Brightness Temperature CMG Band M14	Degrees K	16-bit unsigned integer	0	0 - 40000	0.01
Brightness Temperature CMG Band M15	Degrees K	16-bit unsigned integer	0	0 - 40000	0.01

Brightness Temperature CMG Band M16	Degrees K	16-bit unsigned integer	0	0 - 40000	0.01
Granule Time	HHMM	16-bit signed integer	0	0 - 2355	1
CMG State QA (*see Table 22*)	Bit Field	16-bit signed integer	0	1 - 65535	NA
Number Mapping 1 (*see Table 23*)	None	32-bit unsigned integer	0	0-2097151	NA
Number Mapping 2 (*see Table 24*)	None	32-bit unsigned integer	0	0-2097151	NA
Number 375 m pixels averaged	None	16-bit unsigned integer	0	1 - 200	NA
Number 750 m pixels averaged	None	16-bit unsigned integer	0	1 - 40	NA

3.2. Data product quality & state QA flags

Table 11. QA Flags (8-bit). Note that bit 0 is the Least Significant Bit (LSB).

Bit No.	Parameter Name	Bit Comb.	
0-1	Cloud mask quality	00	Poor
		01	Low
		10	Medium
		11	High
2-3	Cloud detection & confidence	00	Confident clear
		01	Probably clear
		10	Probably cloudy
		11	Confident cloudy
4	Day/Night	0	Day
		1	Night
5	Low sun mask	0	High
		1	Low
6-7	Sun Glint	00	None
		01	Geometry based
		10	Wind speed based
		11	Geometry and wind speed based

Table 12. QA Flags (8-bit). Note that bit 0 is the Least Significant Bit (LSB).

Bit No.	Parameter Name	Bit Comb.	
0-2	Land/Water back-ground	000	Land & desert
		001	Land no desert
		010	Inland water
		011	Sea Water
		100	---
		101	Coastal
		110	---
3	Shadow Mask	0	No cloud shadow
		1	Shadow

4	Heavy aerosol mask	0	No heavy aerosol
		1	Heavy aerosol
5	Snow/ice	0	No snow/ice
		1	Snow or Ice
6	Thin cirrus reflective	0	No cloud
		1	Cloud
7	Thin cirrus emissive	0	No cloud
		1	Cloud

Table 13. Data quality (8-bit). Note that bit 0 is the Least Significant Bit (LSB).

Bit No.	Parameter Name	Bit Comb.	
0	Bad M1 SDR data	0	No
		1	Yes
1	Bad M2 SDR data	0	No
		1	Yes
2	Bad M3 SDR data	0	No
		1	Yes
3	Bad M4 SDR data	0	No
		1	Yes
4	Bad M5 SDR data	0	No
		1	Yes
5	Bad M7 SDR data	0	No
		1	Yes
6	Bad M8 SDR data	0	No
		1	Yes
7	Bad M10 SDR data	0	No
		1	Yes

Table 14. Data quality & ancillary data flag (8-bit). Note that bit 0 is the Least Significant Bit (LSB).

Bit No.	Parameter Name	Bit Comb.	
0	Bad M11 SDR data	0	No
		1	Yes
1	Bad I1 SDR data	0	No
		1	Yes
2	Bad I2 SDR data	0	No
		1	Yes
3	Bad I3 SDR data	0	No
		1	Yes
4	Overall quality of AOT	0	Good
		1	Bad
5	Missing AOT input data	0	No
		1	Yes
6	Invalid land AM input data	0	Valid
		1	Invalid AM Input over Land or over Ocean
7	Missing PW input data	0	No
		1	Yes

Table 15. Data quality & ancillary data flag (8-bit). Note that bit 0 is the Least Significant Bit (LSB).

Bit No.	Parameter Name	Bit Comb.	
0	Missing Ozone input data	0	No
		1	Yes
1	Missing Surface Pressure input data	0	No
		1	Yes
2	Overall quality M1 Surf. Refl. data	0	Good
		1	Bad
3	Overall quality M2 Surf. Refl. data	0	Good
		1	Bad
4	Overall quality M3	0	Good

	Surf. Refl. data	1	Bad
5	Overall quality M4 Surf. Refl. data	0	Good
		1	Bad
6	Overall quality M5 Surf. Refl. data	0	Good
		1	Bad
7	Overall quality M7 Surf. Refl. data	0	Good
		1	Bad

Table 16. Data quality (8-bit). Note that bit 0 is the Least Significant Bit (LSB).

Bit No.	Parameter Name	Bit Comb.	
0	Overall quality M8 Surf. Refl. data	0	No
		1	Yes
1	Overall quality M10 Surf. Refl. data	0	No
		1	Yes
2	Overall quality M11 Surf. Refl. data	0	Good
		1	Bad
3	Overall quality I1 Surf. Refl. data	0	Good
		1	Bad
4	Overall quality I2 Surf. Refl. data	0	Good
		1	Bad
5	Overall quality I3 Surf. Refl. data	0	Good
		1	Bad
6	Unused	-	---
7	Unused	-	---

Table 17. QA Flag (8-bit). Note that bit 0 is the Least Significant Bit (LSB).

Bit No.	Parameter Name	Bit Comb.	
0	Snow present	0	No
		1	Yes
1	Adjacent to cloud	0	No
		1	Yes
2-3	Aerosol quantity	00	Climatology
		01	Low
		10	Average
		11	High
4	Thin Cirrus Flag	0	No
		1	Yes
5	Unused	-	---
6	Unused	-	---
7	Unused	-	---

Table 18. Band Quality Description (16-bit). Bit 0 is LSB.

Bit No.	Parameter Name	Bit Comb.	
0-1	MODLAND QA bits	00	Corrected product produced at ideal quality all bands
		01	Corrected product produced at less than ideal quality some or all bands
		10	Corrected product not produced due to cloud effects all bands
		11	Corrected product not produced due to other reasons some or all bands may be fill value [Note that a value of (11) overrides a value of (01)].
2-3	Cloud State	00	Clear
		01	Cloudy
		10	Mixed
		11	Not set, assumed clear
4-7	Band 1 data quality four bit range	0000	Highest quality
		0111	Noisy detector
		1000	Dead detector, data interpolated in L1B
		1001	Solar zenith >= 86 degrees
		1010	Solar zenith >= 85 and < 86 degrees
		1011	Missing input
		1100	Internal constant used in place of climatological data for at least one atmospheric constant
		1101	Correction out of bounds, pixel constrained to extreme allowable value
		1110	L1B data faulty
		1111	Not processed due to deep ocean or clouds
8-11	Band 2 data quality four bit range		SAME AS BAND 1 ABOVE
12	Atmospheric correction performed	1	Yes
		0	No
13	Adjacency correction performed	1	Yes
		0	No
14	Different orbit from 500 m	1	Yes
		0	No
15	Spare (unused)	-	---

Table 19. Band Quality Description (32-bit). Bit 0 is LSB.

Bit No.	Parameter Name	Bit Comb.	
0-1	MODLAND QA bits	00	corrected product produced at ideal quality -- all bands
		01	corrected product produced at less than ideal quality -- some or all bands
		10	corrected product not produced due to cloud effects -- all bands
		11	corrected product not produced for other reasons -- some or all bands, may be fill value (11) [Note that a value of (11) overrides a value of (01)].
2-5	Band 1 data quality, four bit range	0000	highest quality
		0111	noisy detector
		1000	dead detector, data interpolated in L1B
		1001	solar zenith >= 86 degrees
		1010	solar zenith >= 85 and < 86 degrees
		1011	missing input
		1100	internal constant used in place of climatological data for at least one atmospheric constant
		1101	correction out of bounds, pixel constrained to extreme allowable value
		1110	L1B data faulty
		1111	not processed due to deep ocean or clouds
6-9	Band 2 data quality four bit range		same as band above
10-13	Band 3 data quality four bit range		same as band above
14-17	Band 4 data quality four bit range		same as band above
18-21	Band 5 data quality four bit range		same as band above
22-25	Band 6 data quality four bit range		same as band above
26-29	Band 7 data quality four bit range		same as band above
30	Atmospheric correction performed	1	yes
		0	no
31	Adjacency correction performed	1	yes
		0	no

Table 20. State QA description (8-bit). Bit 0 is LSB.

Bit No.	Parameter Name	Bit Comb.	
0-2	Aerosol Model CMG	000	No AOTR
		001	Smoke (Light)
		010	Smoke (Huge)
		011	Dust
		100	Urban Polluted
		101	Urban Clean
3-7	Unused	-	---

Table 21. State QA description (16-bit). Bit 0 is LSB.

Bit No.	Parameter Name	Bit Comb.	
0-1	Cloud state	00	clear
		01	cloudy
		10	mixed
		11	not set, assumed clear
2	Cloud shadow	1	yes
		0	no
3-5	Land/water flag	000	shallow ocean
		001	land
		010	ocean coastlines and lake shorelines
		011	shallow inland water
		100	ephemeral water
		101	deep inland water
		110	continental/moderate ocean
		111	deep ocean
6-7	Aerosol quantity	00	climatology
		01	low
		10	average
		11	high
8-9	Cirrus detected	00	none
		01	small
		10	average

Bit No.	Parameter Name		Bit Comb.	
		11		high
10	Internal cloud algorithm flag	1		cloud
		0		no cloud
11	Internal fire algorithm flag	1		fire
		0		no fire
12	Snow/ice flag	1		yes
		0		no
13	Pixel is adjacent to cloud	1		yes
		0		no
14	BRDF correction performed	1		yes
		0		no
15	Internal snow flag	1		snow
		0		no snow

Table 22. State QA description (16-bit). Bit 0 is LSB.

Bit No.	Parameter Name	Bit Comb.	
0-1	Cloud state	00	Confident clear
		01	Probably clear
		10	Probably Cloudy
		11	Confident cloudy
2	Cloud shadow	1	Yes
		0	No
3-5	Land/water flag	000	Land & desert
		001	Land no desert
		010	Inland water
		011	Sea Water
		100	---
		101	Coastal
		110	---
		111	---
6	Overall aerosol quantity	0	No
		1	OK
7	Unused	-	---

8	Thin cirrus reflective	1	Yes
		0	No
9	Thin cirrus emissive	1	Yes
		0	No
10	Cloud flag	1	Cloud
		0	No cloud
11-14	Unused	-	---
15	Snow/Ice flag	1	Snow/Ice
		0	No Snow/Ice

3.3. Number Mapping

Table 23. CMG Number Mapping (32-bit). Bit 0 is LSB.

Bit No.	Description
0-15	Number of pixel mapping flagged as adjacent to cloud
16-31	Number of pixel mapping flagged for snow

Table 24. CMG Number Mapping (32-bit). Bit 0 is LSB.

Bit No.	Description
0-15	Number of pixel mapping flagged as cloudy
16-31	Number of pixel mapping flagged as cloud shadow

3.4. Orbit and coverage

Table 25. Orbit and coverage data set (8-bit). Bit 0 is LSB.

Bit No.	Parameter Name	Bit Comb.	orb_cov_1
0-3	Orbit number	range: from 0 to 13 key: from 0000 (0) to 1011 (13)	
4	Scan half flag	0	top half
		1	bottom half
6-7	Land/water flag	000	0.0 – 12.5%
		001	12.5 – 25.0%
		010	25.0 – 37.5%
		011	37.5 – 50.0%
		100	50.0 – 62.5%
		101	62.5 – 75.0%
		110	75.0 – 87.5%
		111	87.5 – 100.0%

4. Caveats and Known Problems

The performance of the atmospheric correction algorithm degrades as the view and solar zenith angles get larger and as aerosol optical thickness gets larger; the algorithm is also less accurate for bands at shorter wavelengths. The level of accuracy of the atmospheric correction is typically

$$\pm(0.005 + 0.05*reflectance)$$

under favorable conditions (not high aerosol). The look-up tables used in the atmospheric correction algorithm also assume upper limits of 5.0 for aerosol optical thickness and 75° for solar zenith angles.

5. Data ordering (& browsing)

5.1. Where can I brows data

All of the file types listed as 'publically available' in Table 2 can be brows from the following website:

VIIRS Land Global Browse Images

Link: http://landweb.nascom.nasa.gov/cgi-bin/NPP/browse/NPPbrowse.cgi

5.2. Where to get data from

All of the file types listed as 'publically available' in Table 2 can be obtained by ftp from the following websites (others will come soon):
Link: ftp://ladsweb.nascom.nasa.gov/

5.3. Data product granule ID

All archived data is accessed by its LOCALGRANULEID. For data in the sinusoidal grid, the LOCALGRANULEID is constructed like this:

Example 1: NPP_DSRFLD_L2GD.A2015203.h21v11.C1_03002.2015214100707.hdf

NPP_DSRFLD_L2GD: product name (VIIRS/NPP Surface Reflectance Daily L2G 500 m and 1 km)

A20015203: Acquisition year (2015) and Julian day (203)

H21v11: tile ID (see Figure 2)

C1_03002: Collection 1

2015214100707: Production year (2015), Julian day (214), and time (10:07:07)

For Climate Modeling Grid data (CMGs), the LOCALGRANULEID is constructed like this:

Example 2: NPP_SRFLIP_CMG.A2015293.C1_03002.2015295042946.hdf

NPP_SRFLIP_CMG: product name (NPP/VIIRS Surface Reflectance Daily L3 Global DDR 0.05 Deg CMG)

A2015293: Acquisition year (2015) and Julian day (293)

C1_03002: Collection 1

2015295042946: Production year (2015), Julian day (295), and time (04:29:46)

5.4. Data viewing tools

a) Imager (platform: Linux)

A software tool specifically designed by the MODIS LSR SCF for viewing surface reflectance suites. *Link:* http://modis-sr.ltdri.org/pages/software.html

b) HDFLook (platforms: SUN, AIX, SGI, Linux, MacOSX, Cygwin)

A multifunctional data processing and visualization tool for land, ocean and atmosphere MODIS data. *Link:* http://www-loa.univ-lille1.fr/Hdflook/hdflook_gb.html

c) ENVI (platforms: Windows & Linux)

A software for the visualization, analysis, and presentation of all types of digital imagery.

Link: http://www.ittvis.com/envi/

d) HDF Explorer (platform: Windows)

A software environment where data are first viewed in a tree-like interface, and then optionally loaded and visualized in a variety of ways. *Link:* http://www.space-research.org/